Understanding and managing climate variability and change in the Big Hole River watershed

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PACE Postdoctoral Fellow (NCAR)

Webinar Meeting, August 4th, 2011

USGS science for a changing world

NCAR

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Goal of PACE fellowship is to connect climate information with decision-making

PACE

(Postdocs Applying Climate Expertise)

Climate Center:

National Center for Atmospheric Research, Boulder, CO

Climate knowledge production

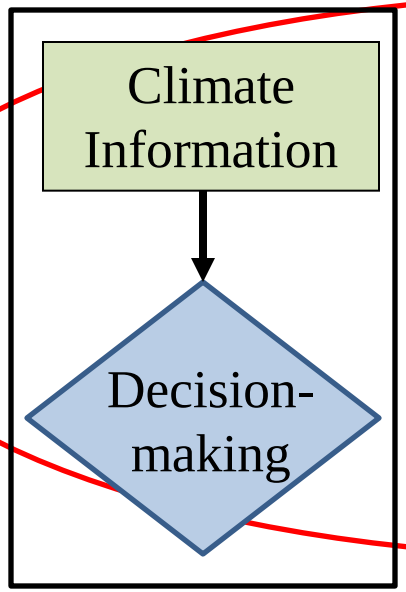
Decision-Making Institute:

Northern Rocky Mountain Science Center, Bozeman, MT

Impact and response

Focus is on natural resource management in the Northern Rockies

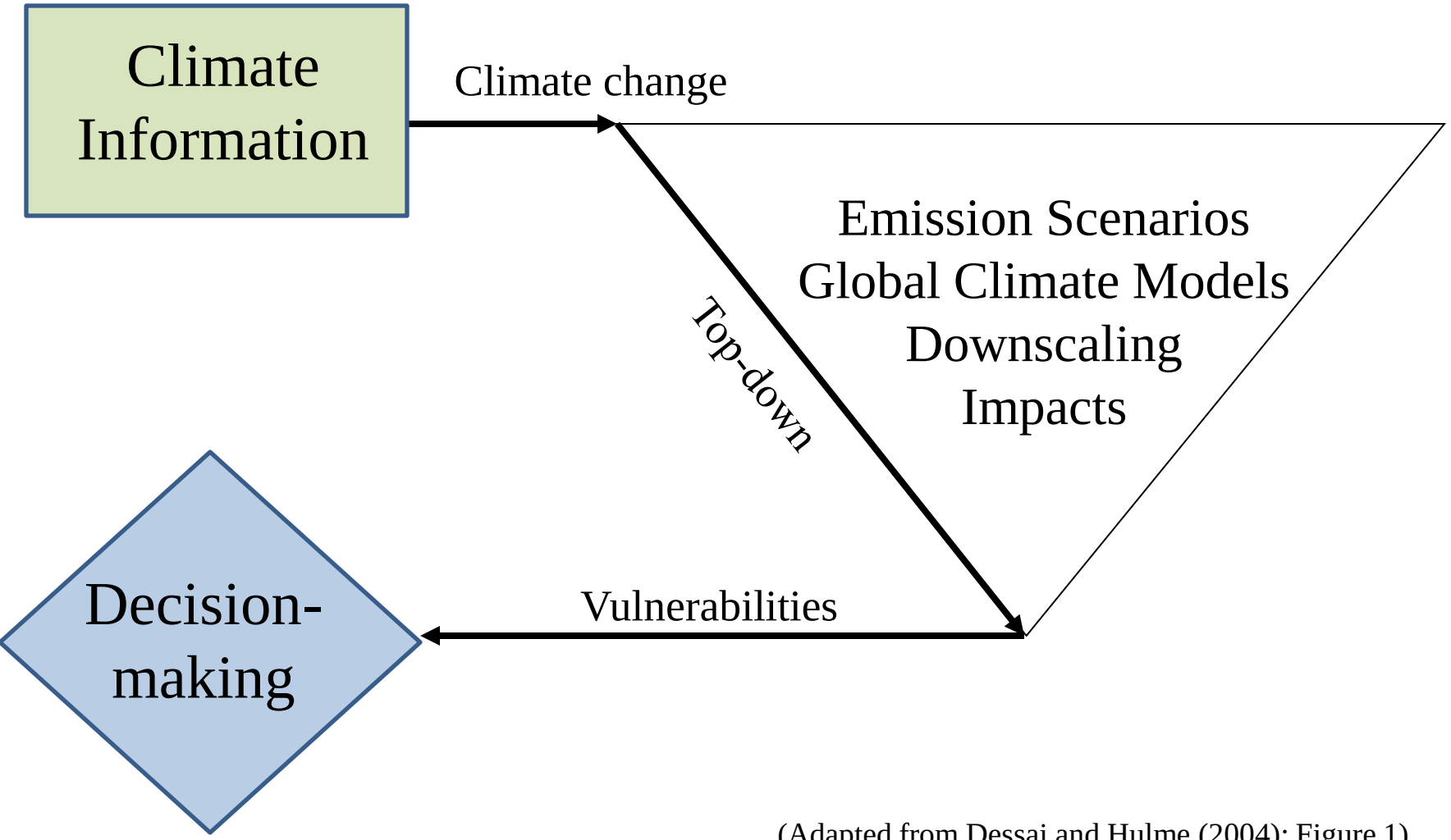
Agenda



1. How can climate information be incorporated into adaptation planning?

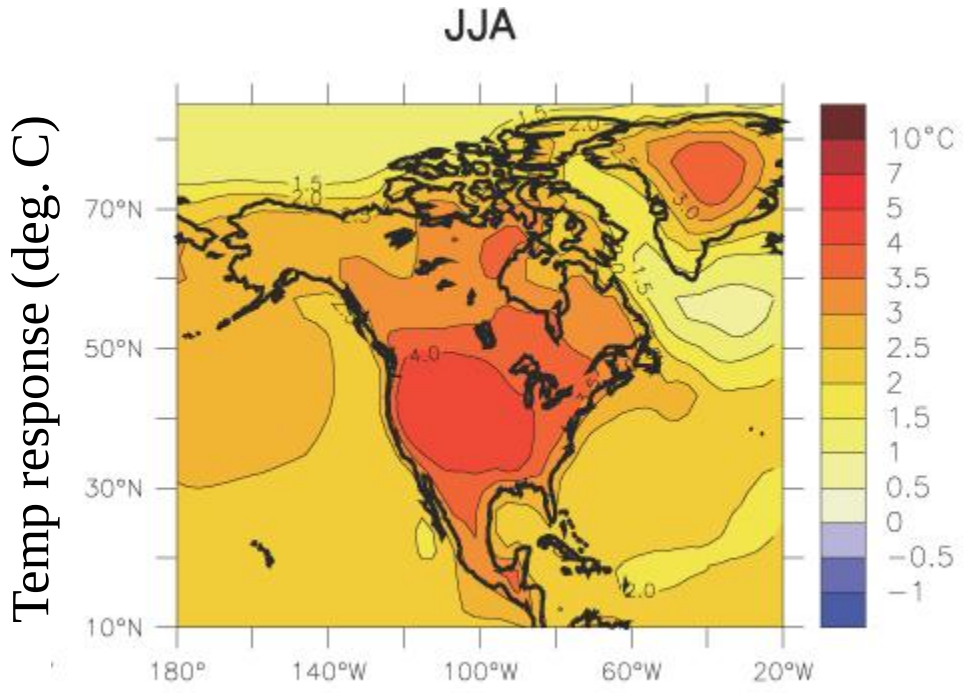
2. Big Hole River case study

Climate change information is often considered from the top-down



(Adapted from Dessai and Hulme (2004); Figure 1)

Top-down does address vulnerability questions and motivates action…



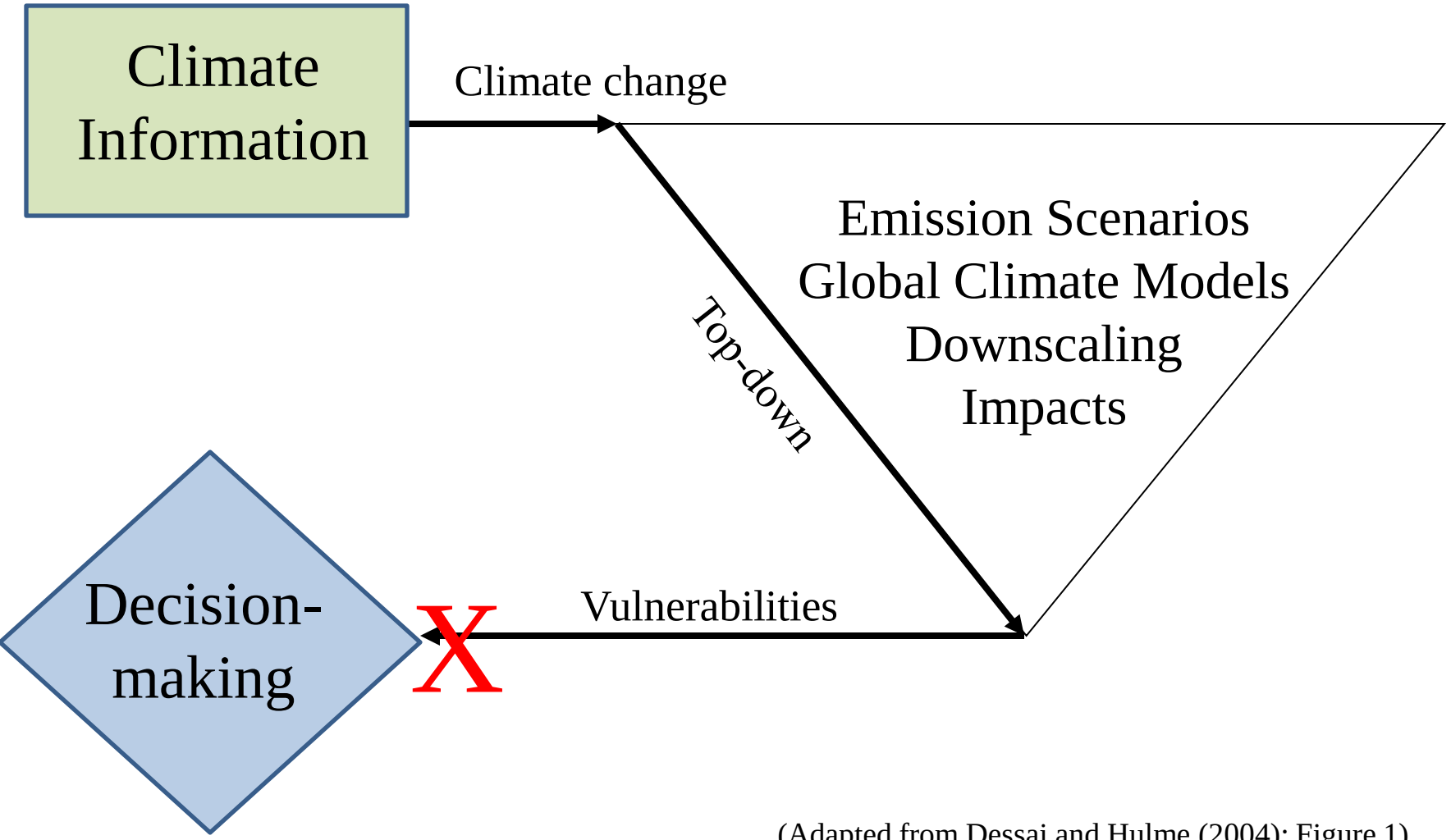
…but issues still exist:

-Scale, uncertainty, and variability

-Applicability to decisions or actions

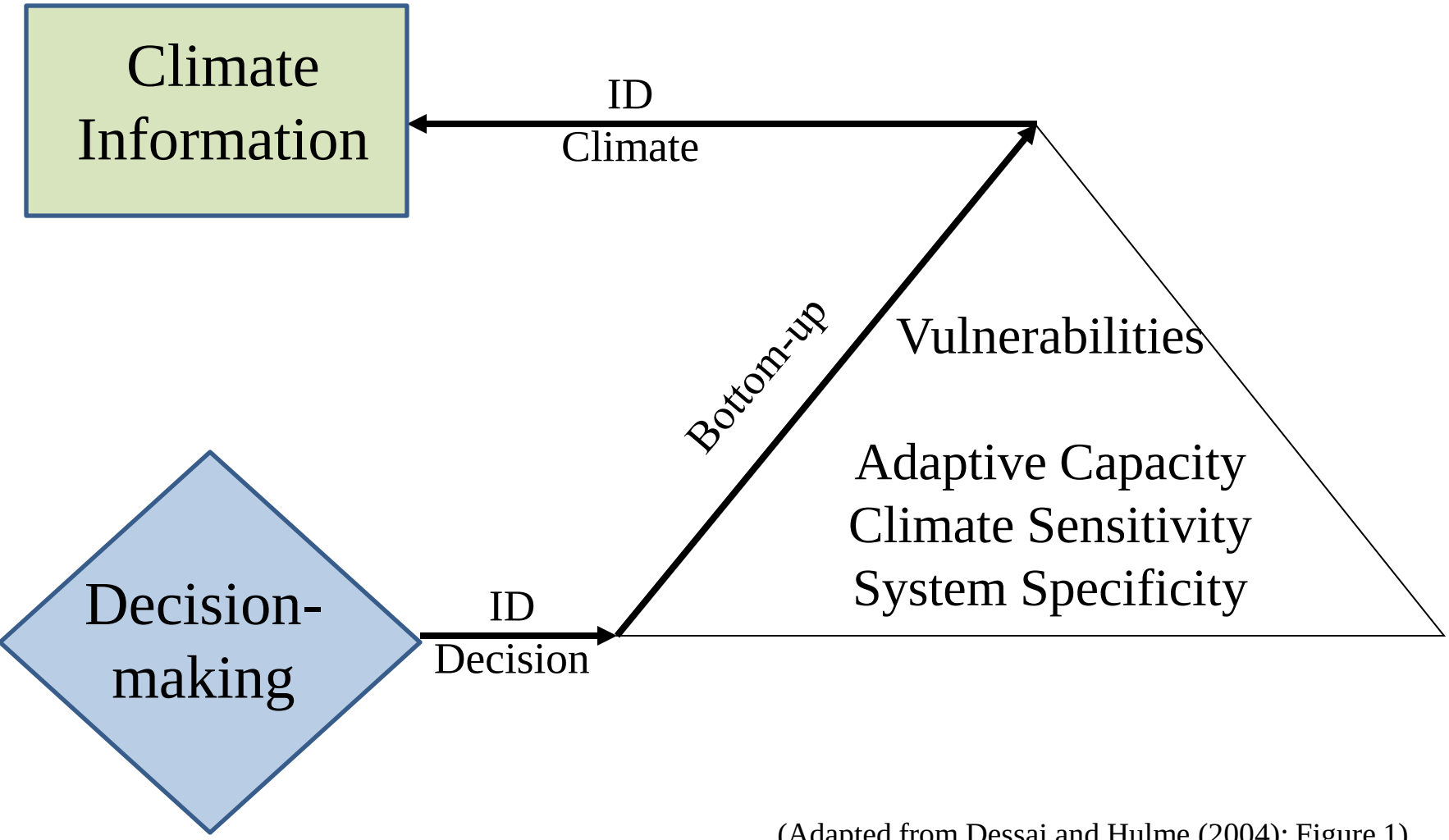
(IPCC (2007); Figure 11.12)

Few top-down approaches result in adaptation measures



(Adapted from Dessai and Hulme (2004); Figure 1)

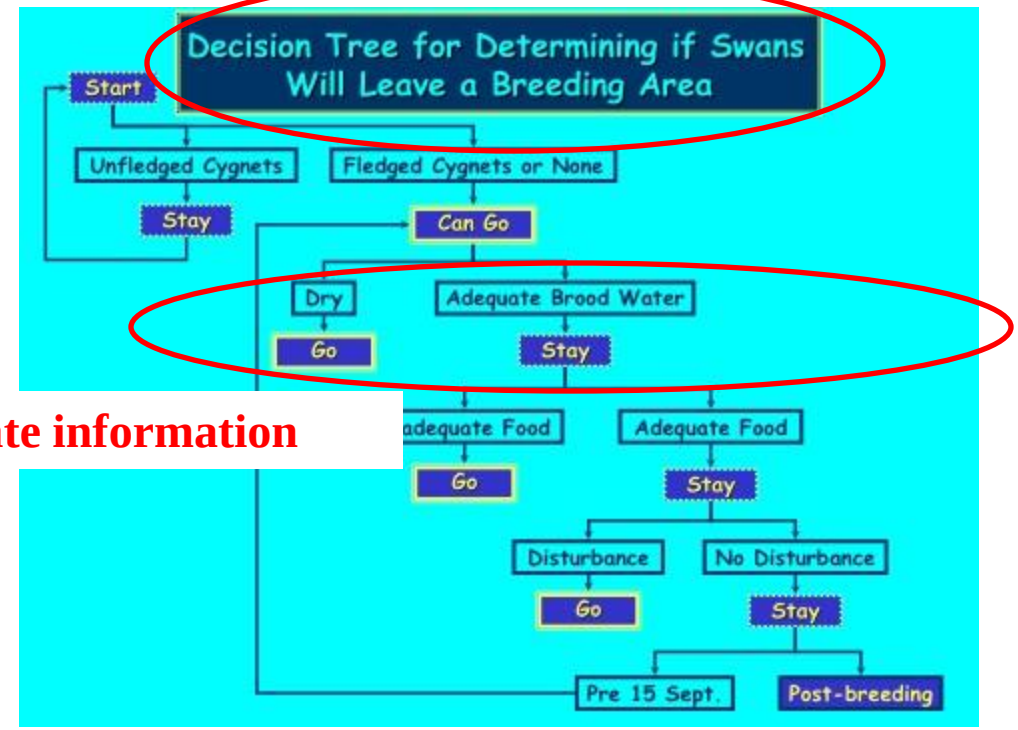
Bottom-up methods provides a complementary approach



(Adapted from Dessai and Hulme (2004); Figure 1)

Bottom-up identifies specific decisions and needed climate information

Specific Decision



Climate information

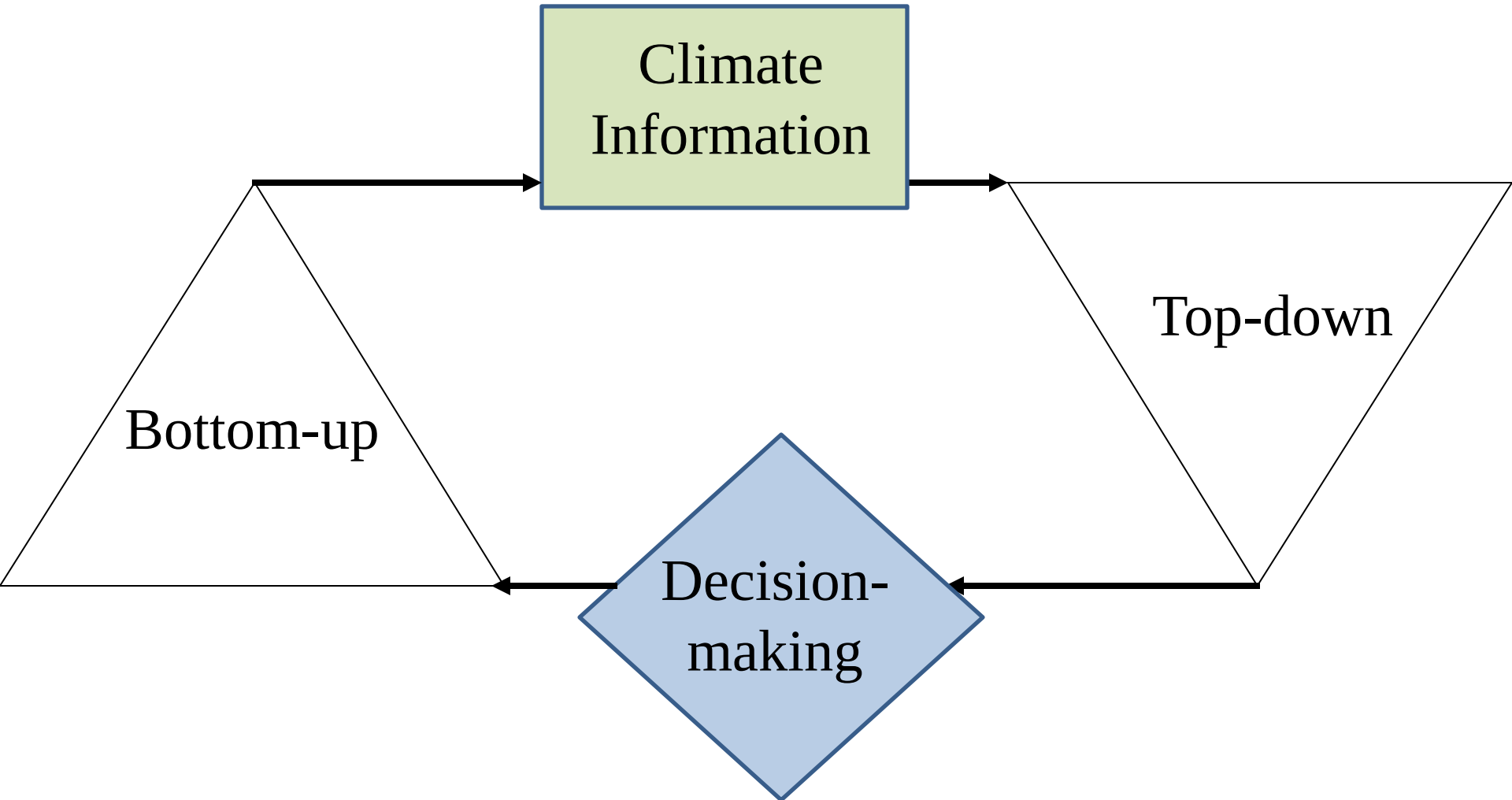
…but issues still exist:

-Climate is only part of the decision

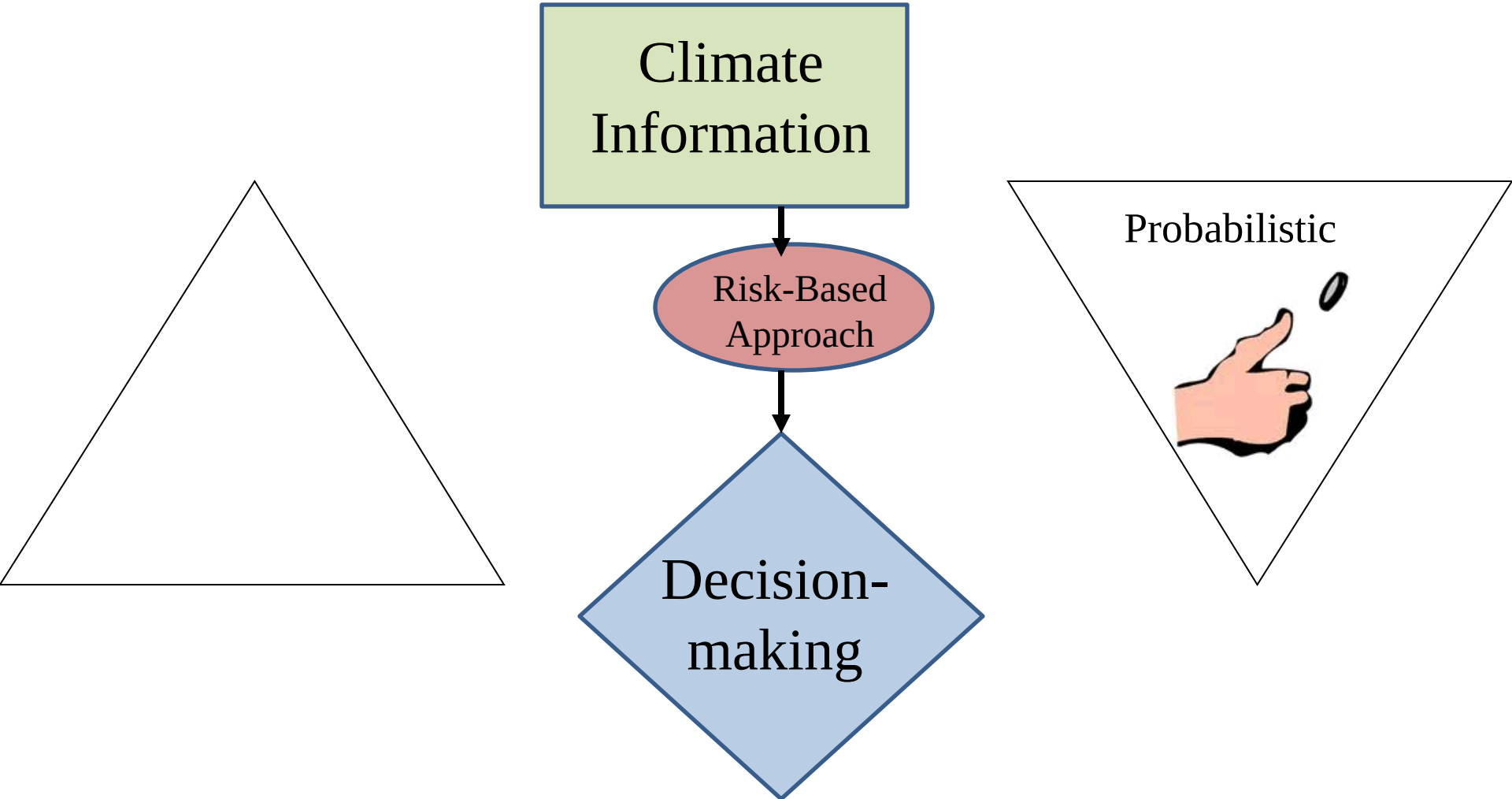
-Requires in-depth system knowledge

(Sojda 2002)

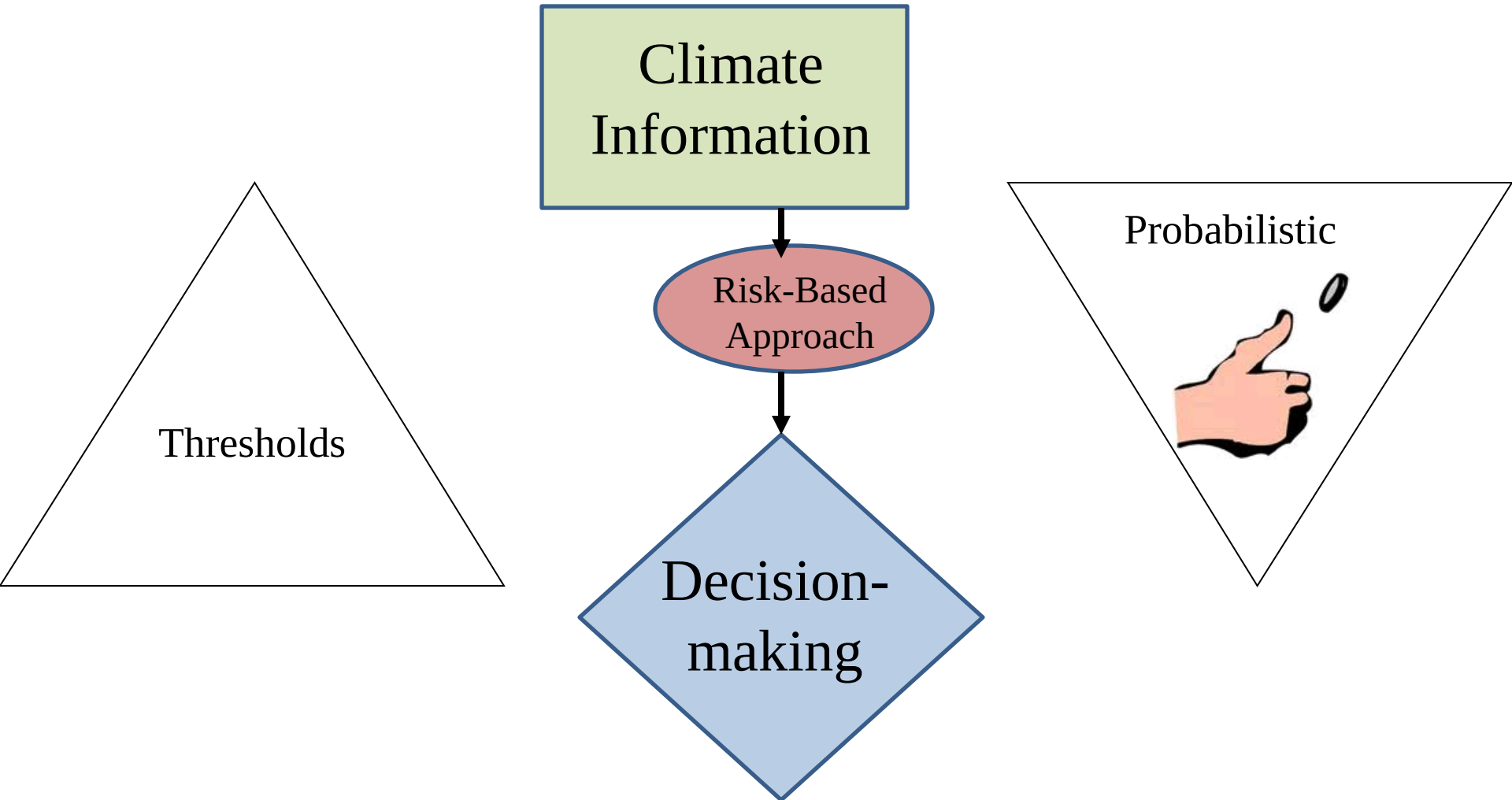
Adaptation planning will benefit from a combined approach



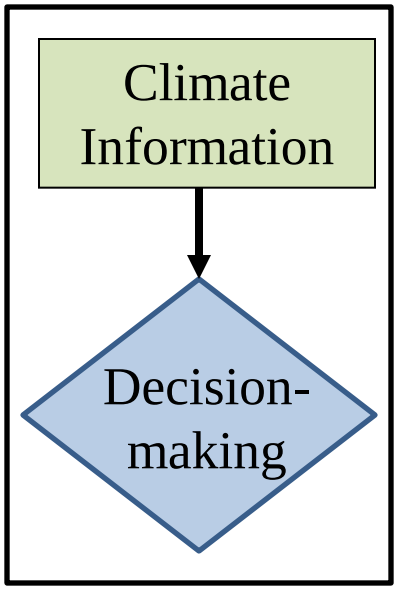
Risk-based approaches can incorporate probabilistic information



Thresholds can serve as meaningful organizing point



Agenda



1. How can climate information be incorporated into adaptation planning?

2. Big Hole River case study

Case Study: Big Hole River low-flows

USGS Wisdom gage is key location for management of fluvial Arctic grayling, a species of conservation concern.

http://www.fws.gov/mountain-prairie/species/fish/grayling/grayling.htm

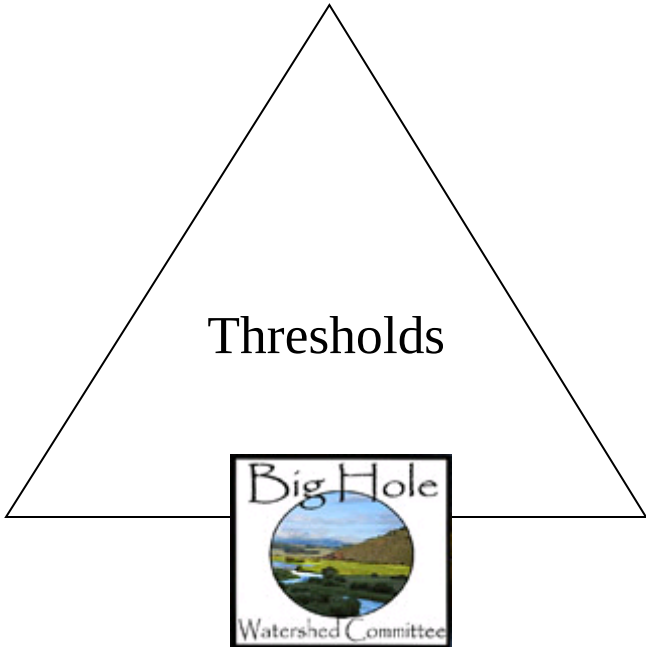
Decreased summer flows and grayling declines have motivated conservation efforts

Candidate Conservation Agreement with Assurances (CCAA)

Candidate Conservation Agreement with Assurances (CCAAs) offer a form of "conservation insurance"

- **Site-specific plans to improve grayling habitat**
  - **Return in-stream flows, riparian habitat restoration, reduce entrainment, remove fish barriers**
- **Protects landowners from further regulation if grayling gets listed as endangered**

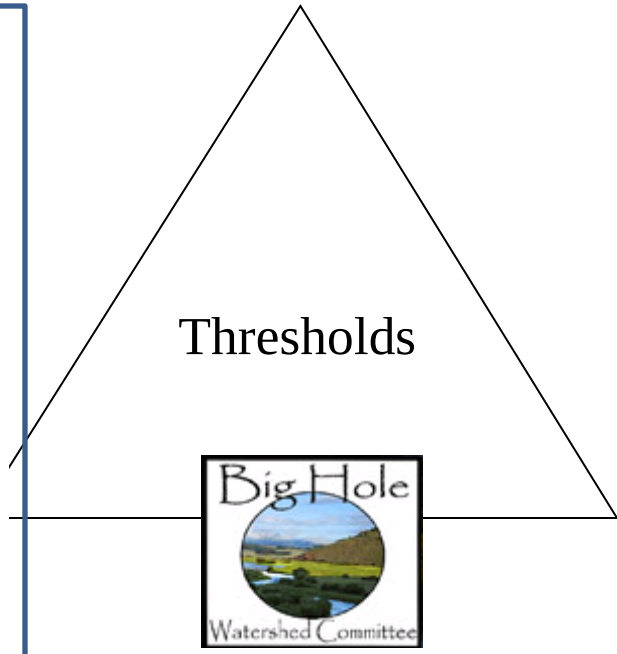
Big Hole River Drought Management Plan identifies fish-relevant and decision-bearing flow thresholds



Big Hole River Drought Management Plan identifies fish-relevant and decision-bearing flow thresholds

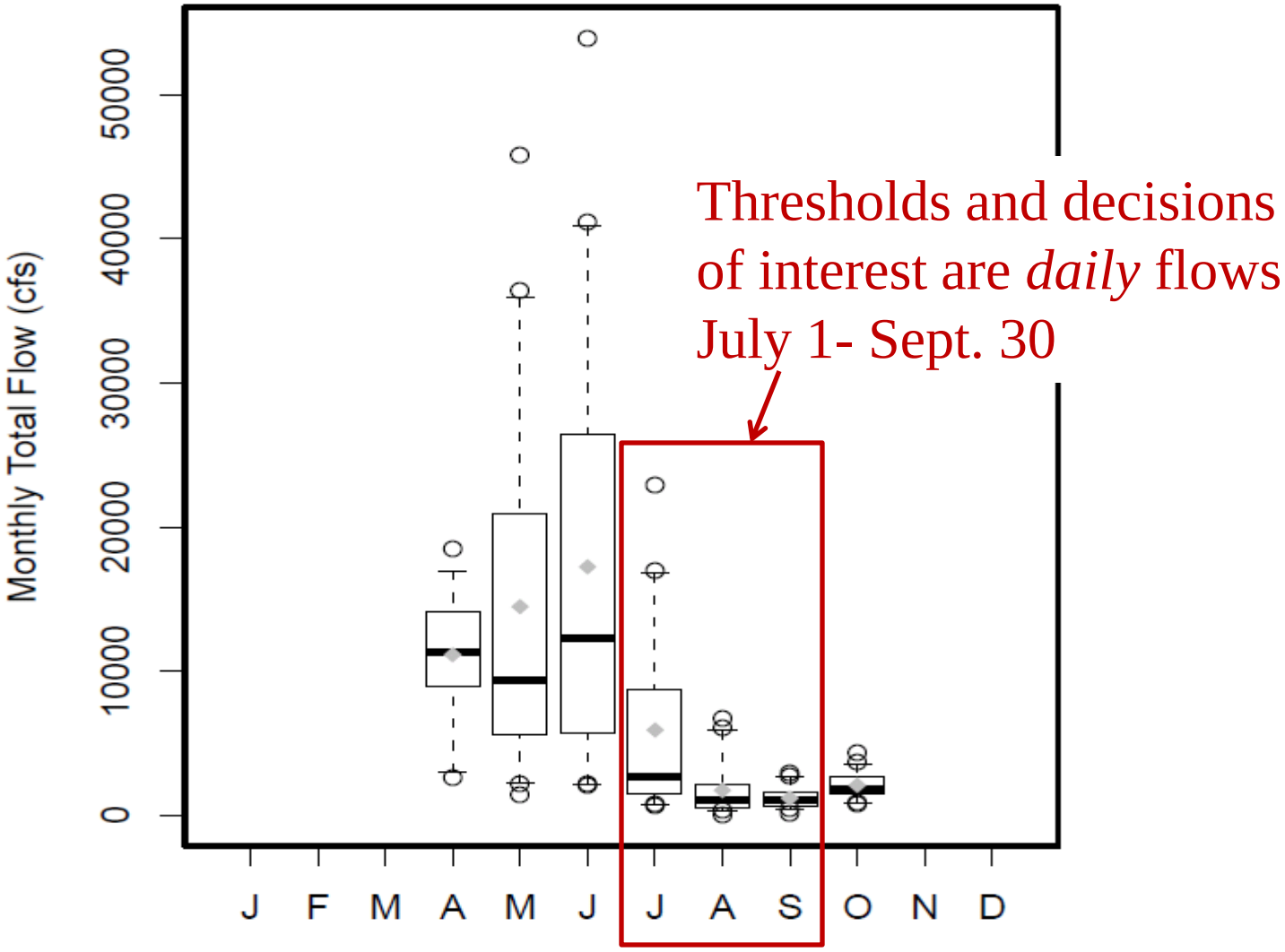
Summer (July 1- Sept 30)

Thresholds	**Decisions**
***Flows** – Monitored at the USGS Wisdom Gauge*	
160 cfs	May 15 – June 30. When flows decrease below 160 cfs a phone tree will be used to contact water users advising of flow conditions and encouraging conservation measures.
60 cfs	*DNRC and MFWP officials will meet with the Big Hole Watershed Committee to* present data; formulate options including voluntary reduction of irrigation, stock water diversions, municipal water use, angling, and encourage the use of stock watering wells; and prepare to take action. A phone tree is initiated to advise water users, outfitters, and anglers of low water conditions and encourage conservation measures.
40 cfs	Notice to outfitters and anglers requesting they voluntarily limit their angling activities to earlier, cooler hours of the day . Well use will be encouraged for stock watering. A phone tree will advise water users and outfitters of low water conditions and encourage conservation measures. The media will be contacted and news articles released to inform publics of low flow conditions.
20 cfs	FWP will close the upper river to fishing, MFWP will close the upper river to fishing, and will not conduct electrofishing surveys (subject to approval or change by the Fluvial Grayling Workgroup). Voluntary reduction of irrigation and public municipal water use is initiated, and continued well use for stock watering encouraged. The phone tree is again initiated to contact water users advising of extreme low water conditions and encourage conservation measures. The media is contacted and informed of fishing closures and encourages public conservation efforts. The river remains closed until flows exceed 40 cfs for seven consecutive days.

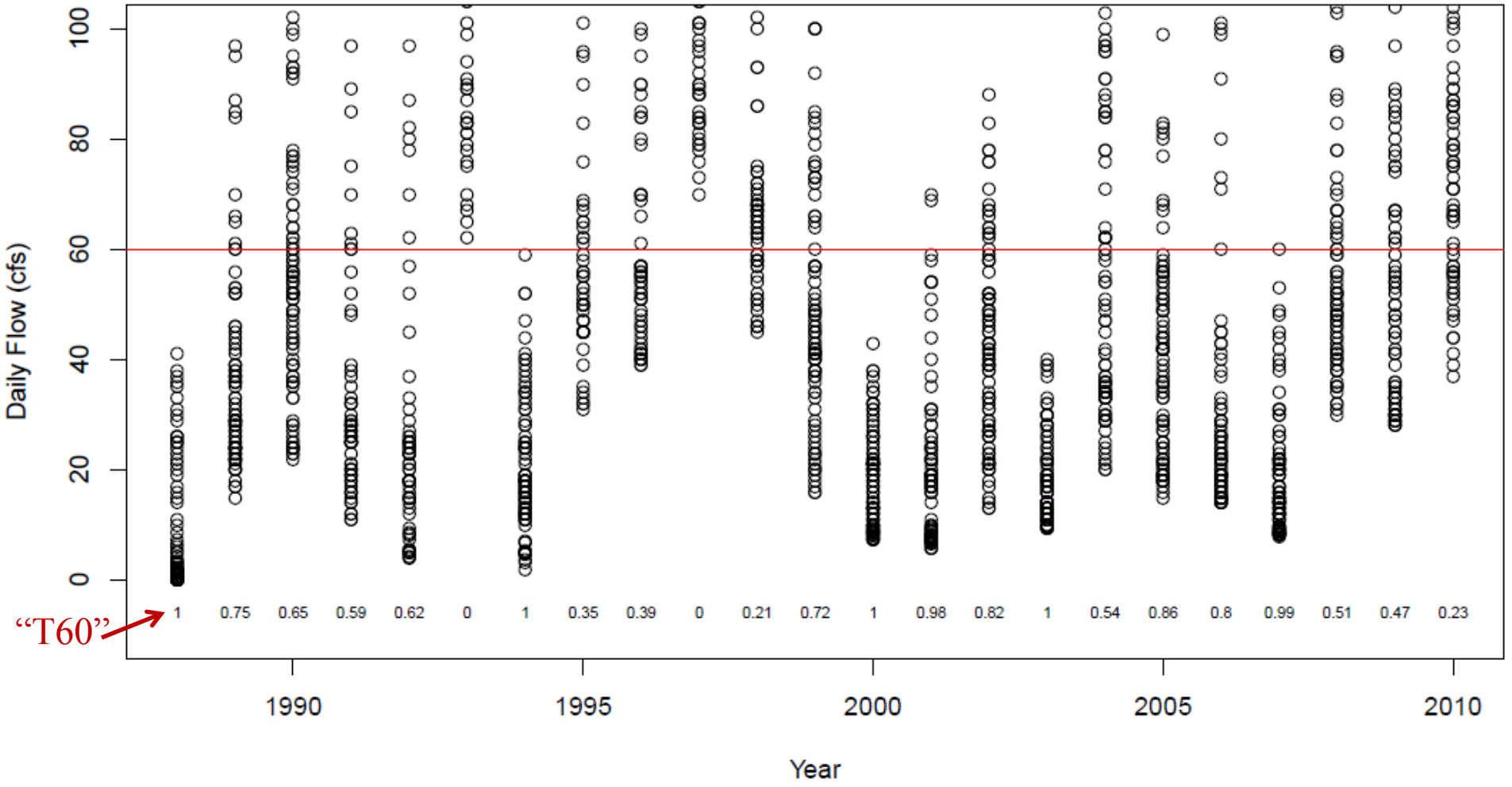


Understanding Wisdom flow characteristics and drivers will help inform management

Wisdom flow records show variability in monthly flows



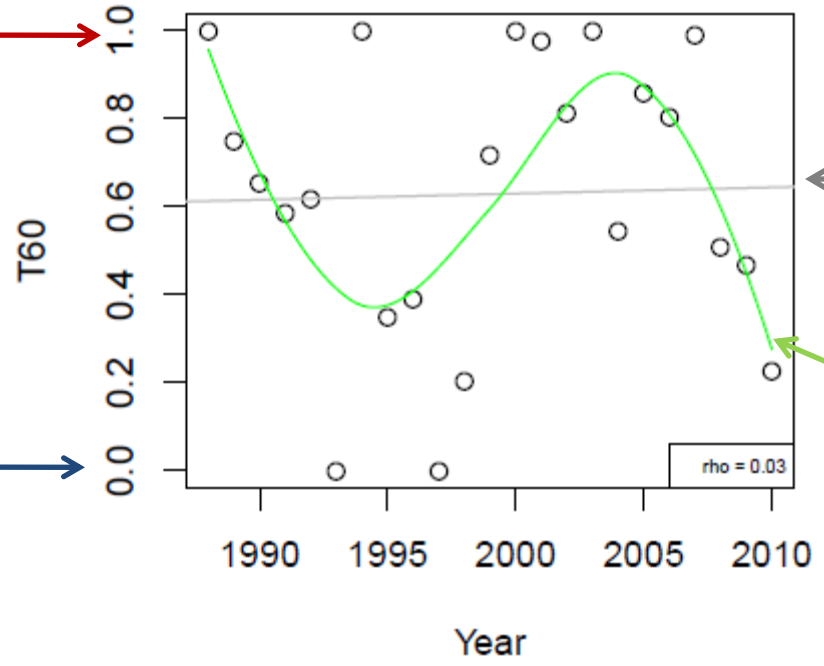
60 cfs threshold exceedance (T60) varies from 0% to 100% over summer record!



Large variability in T60, but no significant “trend”

(From July 1-Sep 30, All flows below 60 cfs)

(From July 1-Sep 30, No flows below 60 cfs)



No “trend”

Large variability

Can we explain T60 in terms of climate?

$$T60 = f(??)$$

Predictors	
Climate	TAVG
	TMAX
	PCP
	SWE
Climate Indices	PDO
	PDSI
	MEI
	ENSO 3.4
Large Scale Variables	SST
	SLP

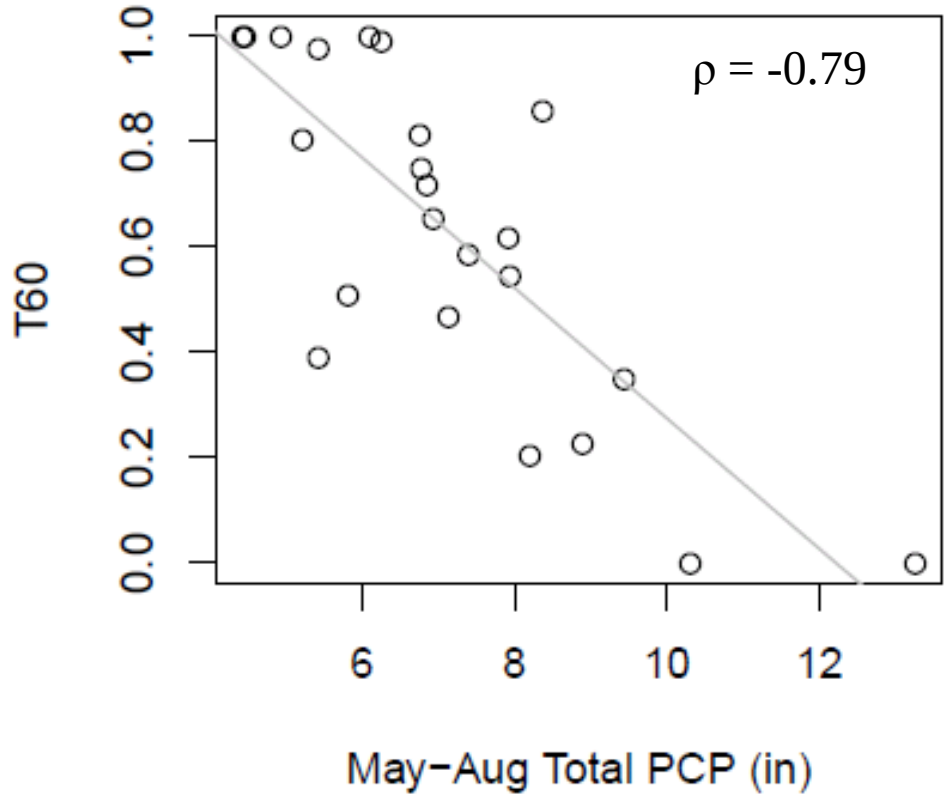
"Best" fit model using linear regression

Regression explains 78% of variance

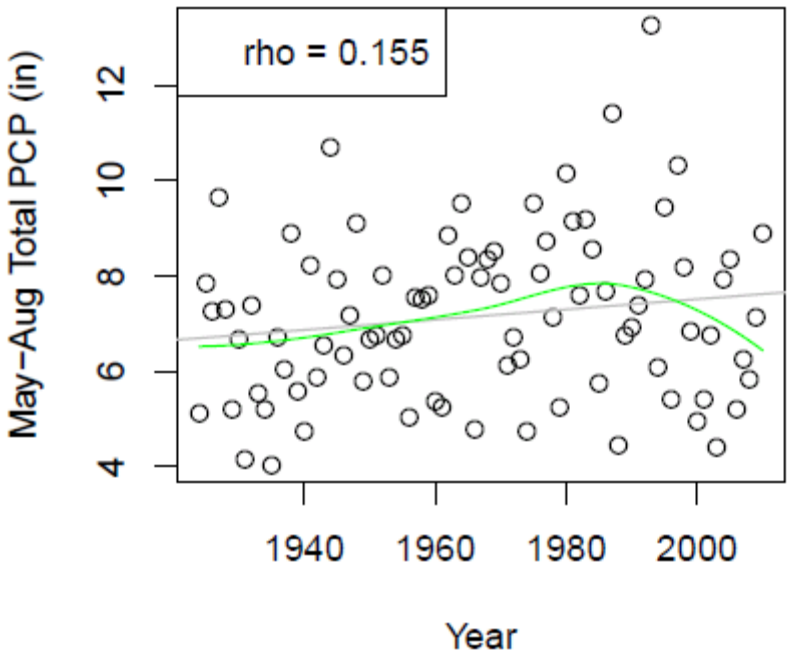
$$T60 = 2.1 - 0.11(PCP_{MJJA}) - 0.019(SWE_{May1})$$

Adj. $R^2 = 0.78$

May - Aug precipitation has the strongest influence on T60



May - Aug precipitation has slight increasing trend

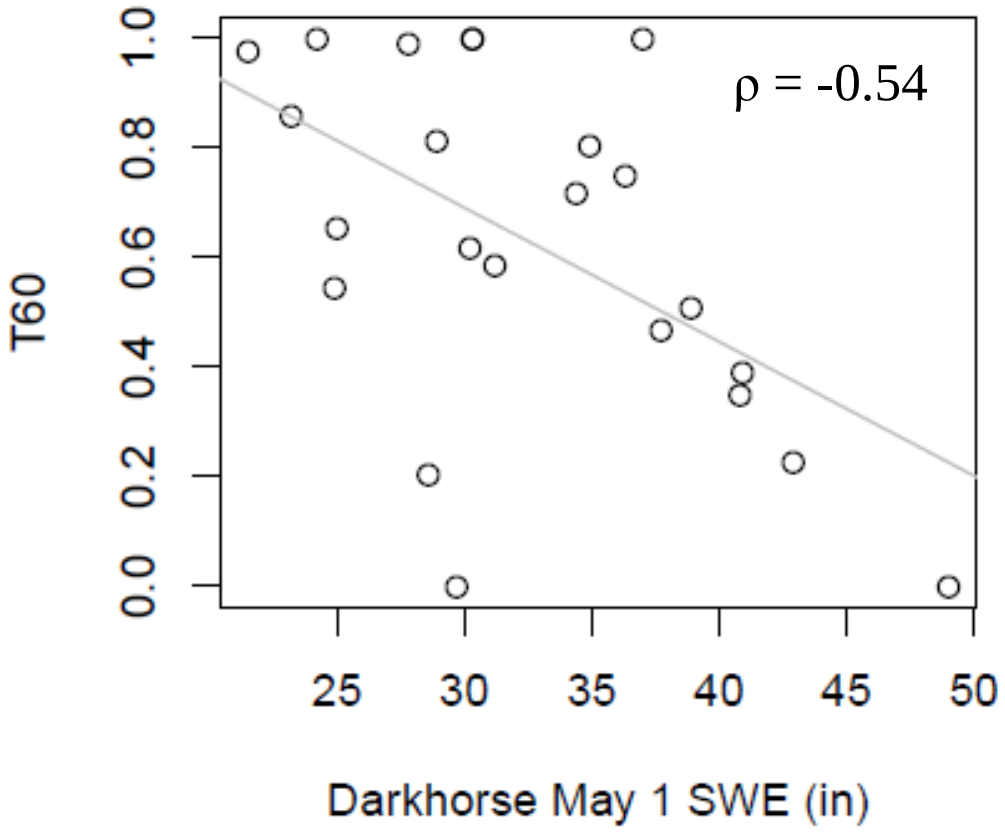


Regression explains 78% of variance

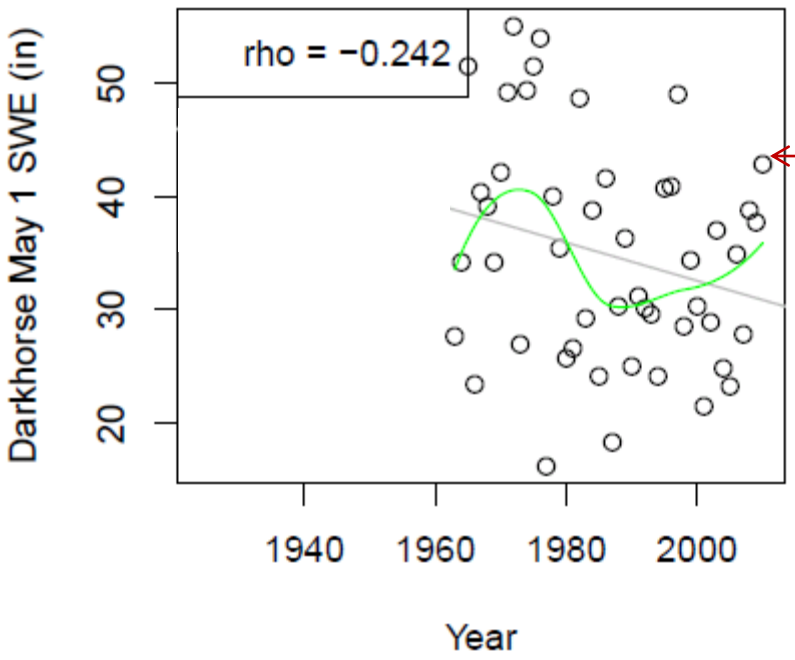
$$T60 = 2.1 - 0.11(PCP_{MJJA}) - 0.019(SWE_{May1})$$

Adj. $R^2 = 0.78$

Darkhorse Snotel May 1 SWE has inverse association with T60



May 1 SWE has decreasing trend, but recent increase



2011
42.9 in

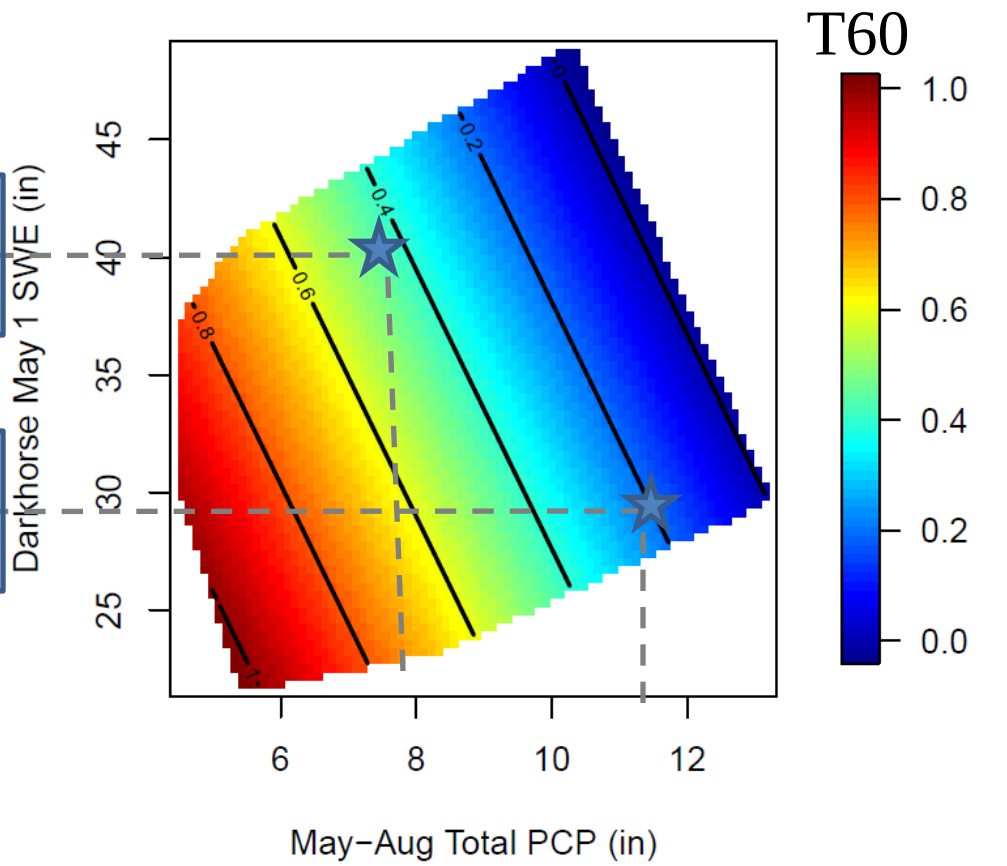
Decreasing spring SWE also observed for larger NRM area (Pederson et al. 2011)

Contour underscores importance of spring/summer PCP

$$T60 = 2.1 - 0.11(PCP_{MJJA}) - 0.019(SWE_{May1})$$

↑SWE ↓ PCP

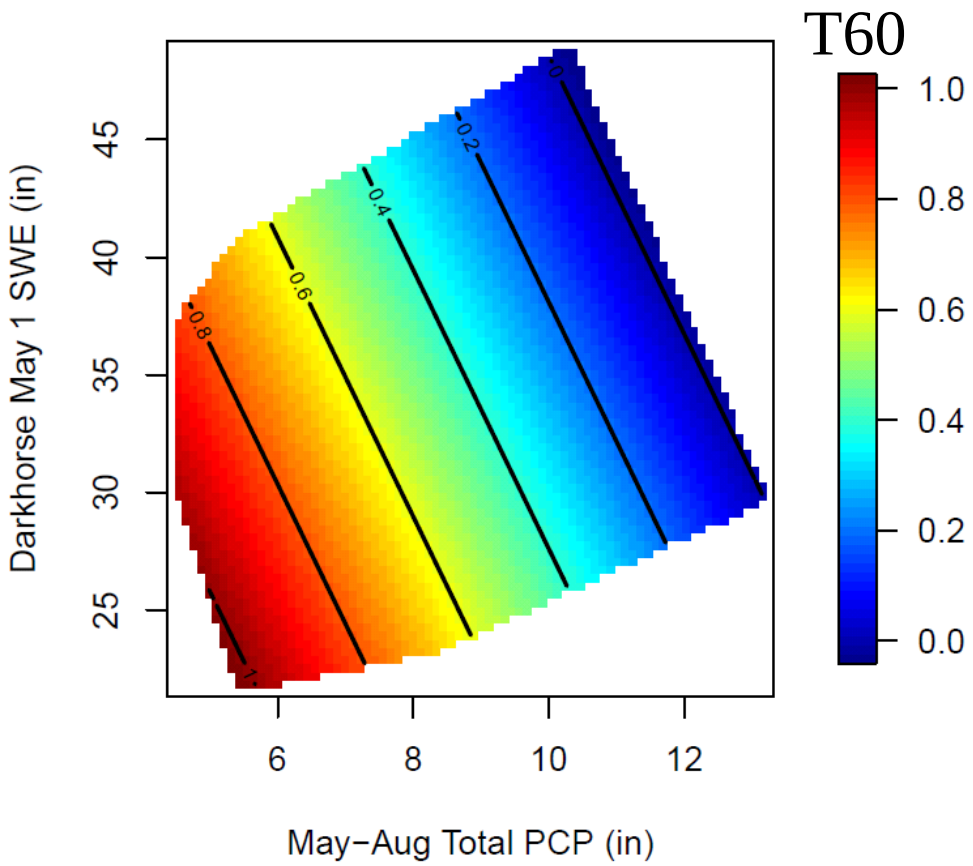
↓SWE ↑ PCP



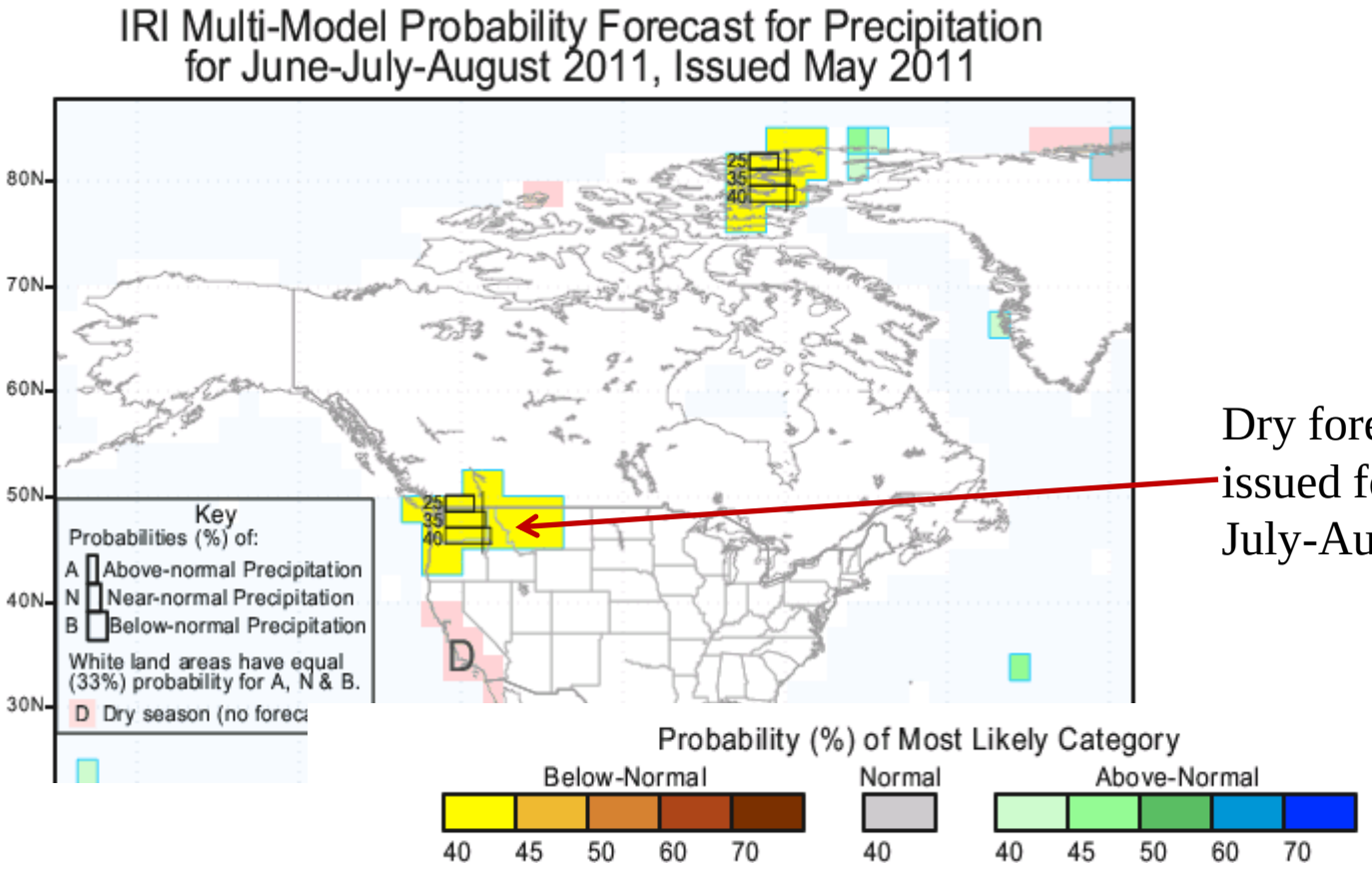
Importance of PCP also noted for larger NRM area (Pederson et al. 2011)

Relationship is useful for:
(i) seasonal prediction, (ii) future projection

$$T60 = 2.1 - 0.11(PCP_{MJJA}) - 0.019(SWE_{May1})$$

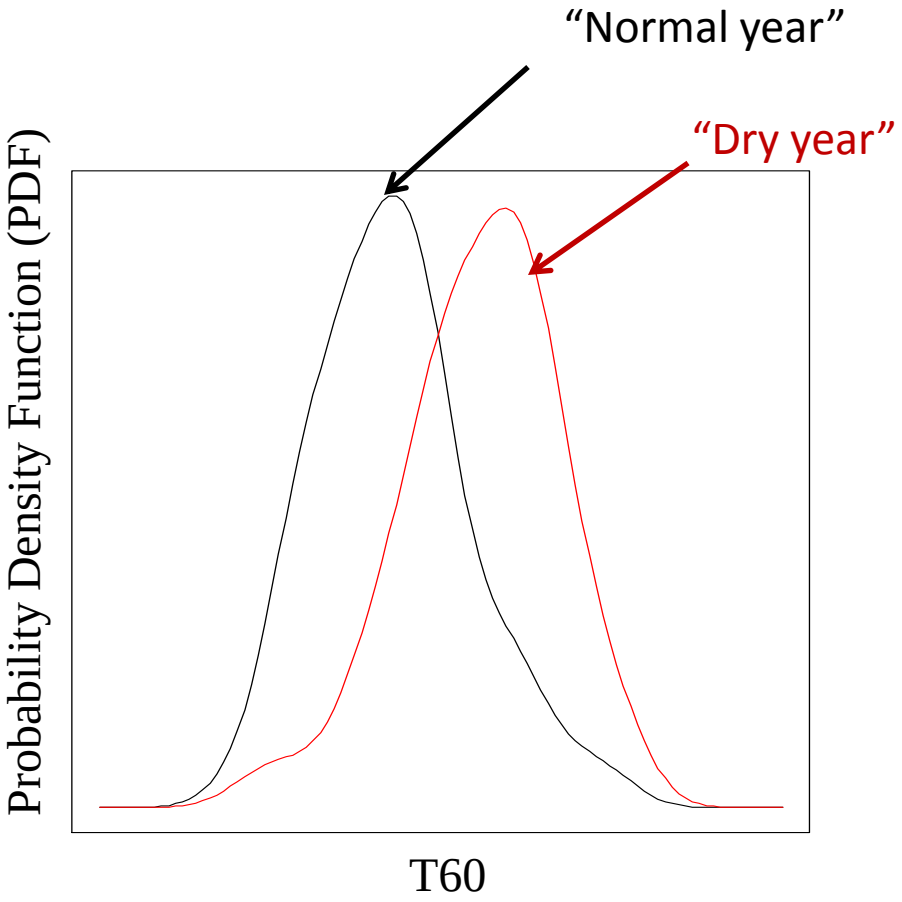


(i) Precip forecasts could be used to create a May 1st T60 outlook



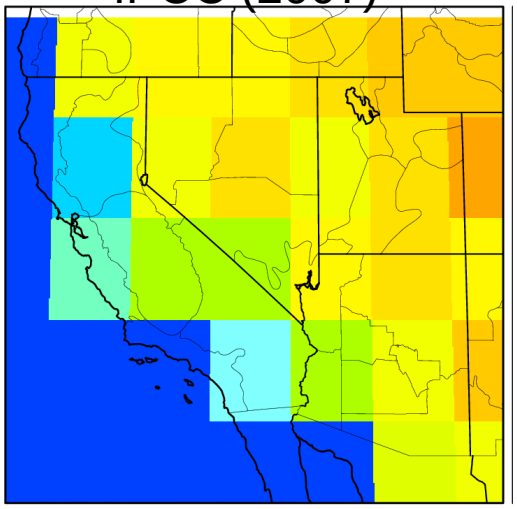
Dry forecast issued for June-July-Aug 2011

Probabilistic outlook could motivate anticipatory actions

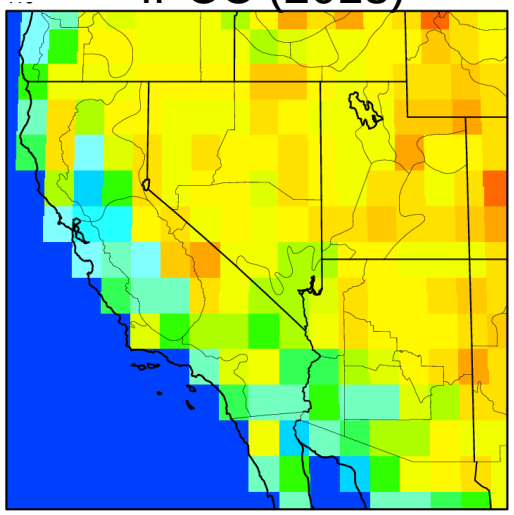


(ii) Future projections of T60 can benefit from improved climate modeling and resolution

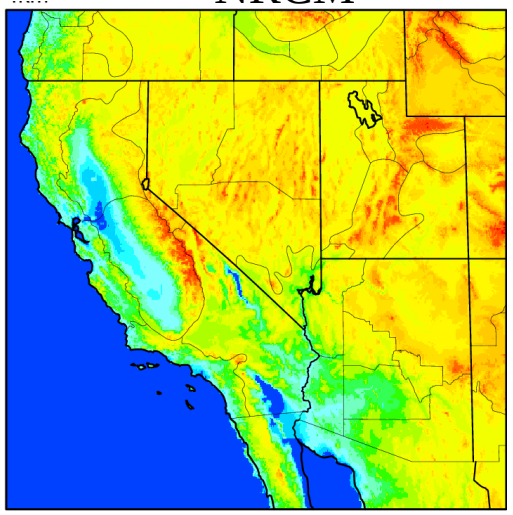
IPCC (2007)



IPCC (2013)



NRCM*

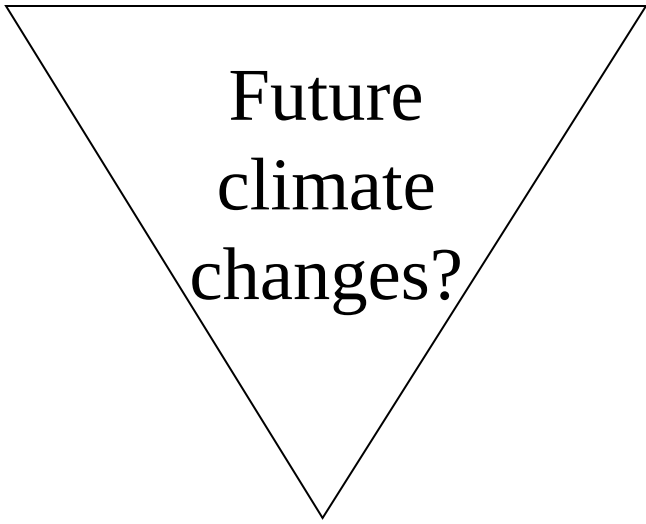


* Nested Regional Climate Model

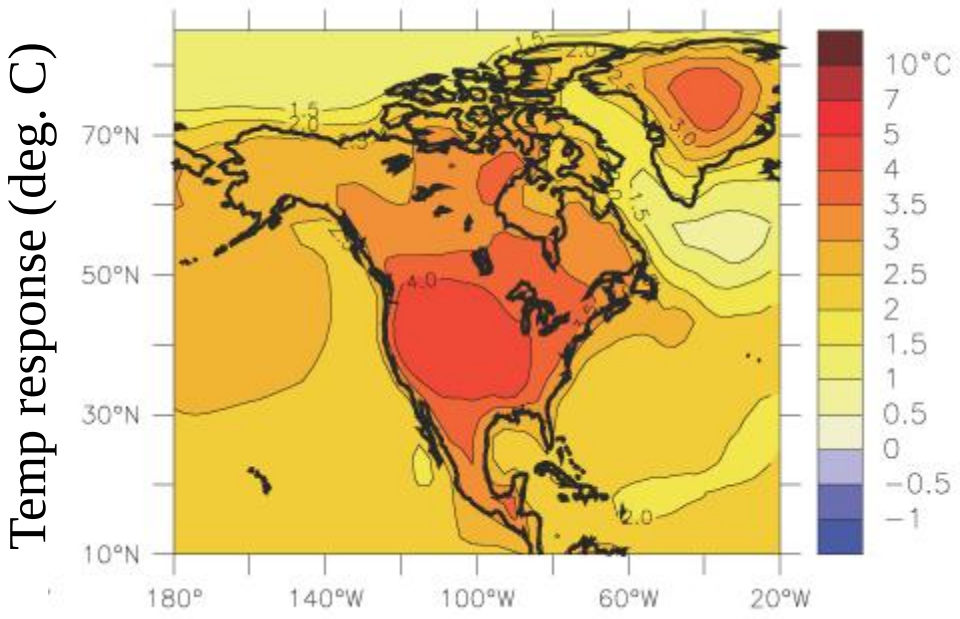
(Hurrell 2008;
Holland et al. 2010)

NCAR

Goal is to increase system resiliency to climate variability and change



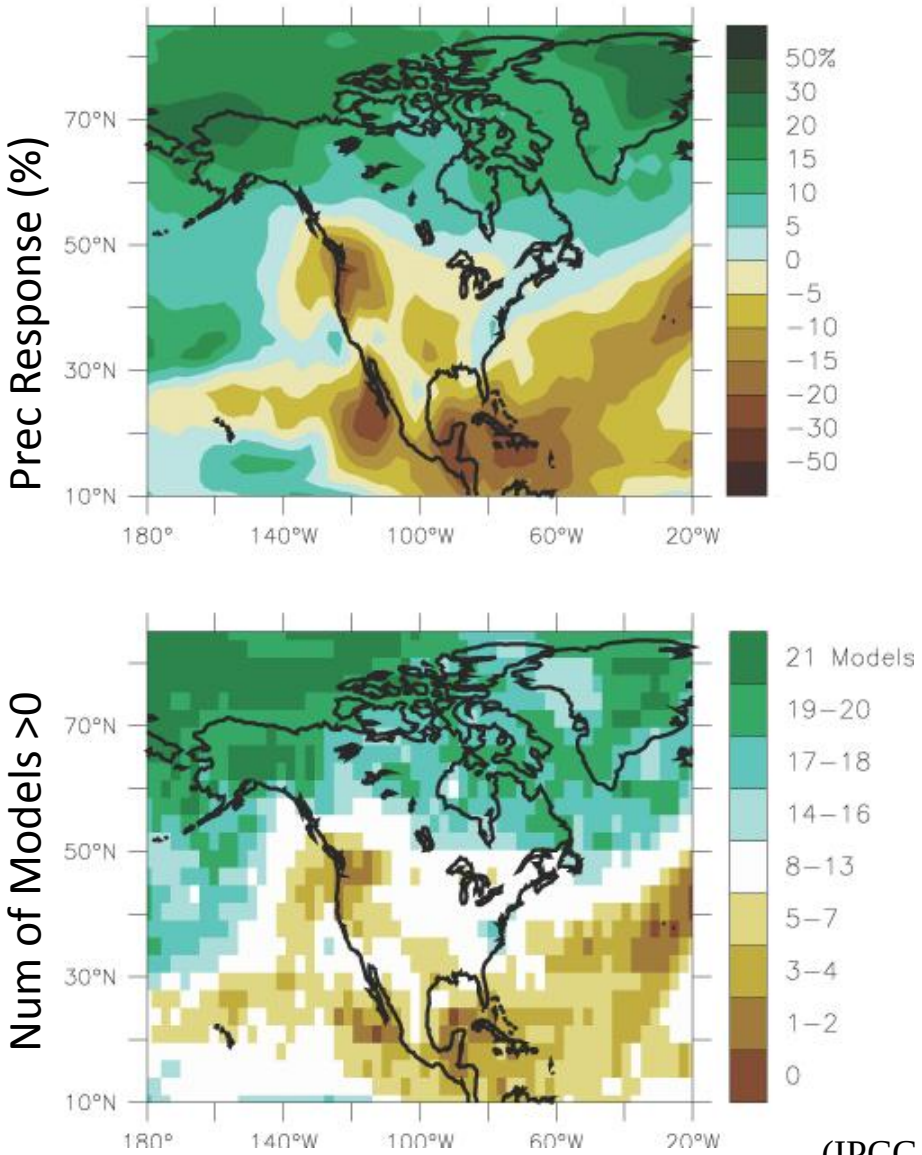
Global models agree that temperatures will continue to increase…



… Indicating earlier snowmelt and decreased spring SWE

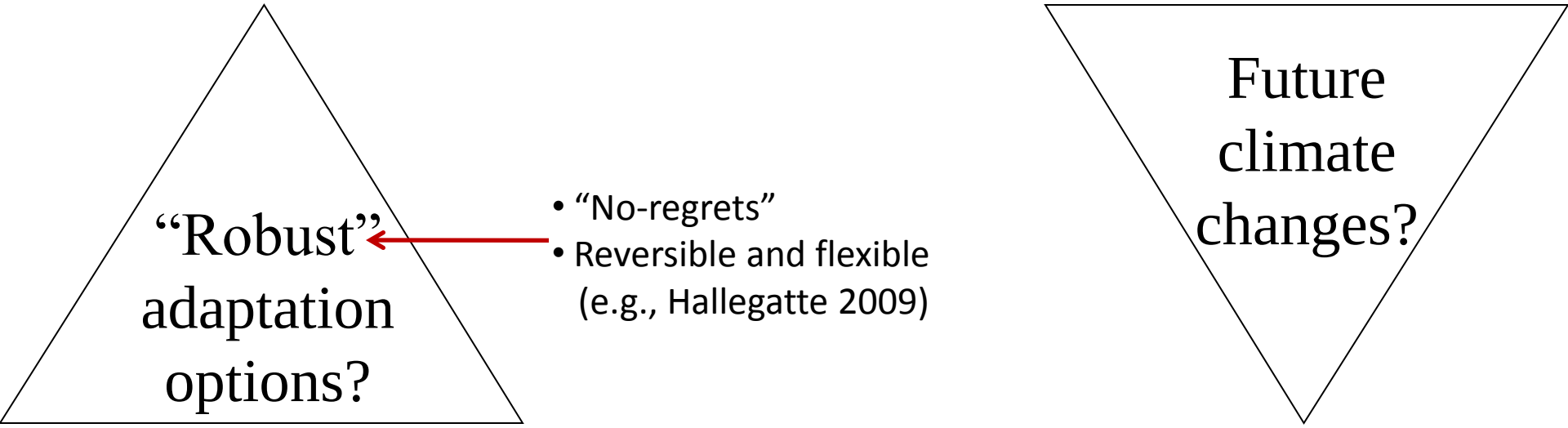
(IPCC (2007); Figure 11.12)

Models indicate summer precipitation reduction in Western US, but results are uncertain



(IPCC (2007); Figure 11.12)

Goal is to increase system resiliency to climate variability and change



Next step:
Regional climate models

Management factors may play a role in increasing system resiliency

$$T60 = \mathrm{f}(PCP_{MJJA}, SWE_{May1}, \textbf{Management?})$$

(1) CCAA influence

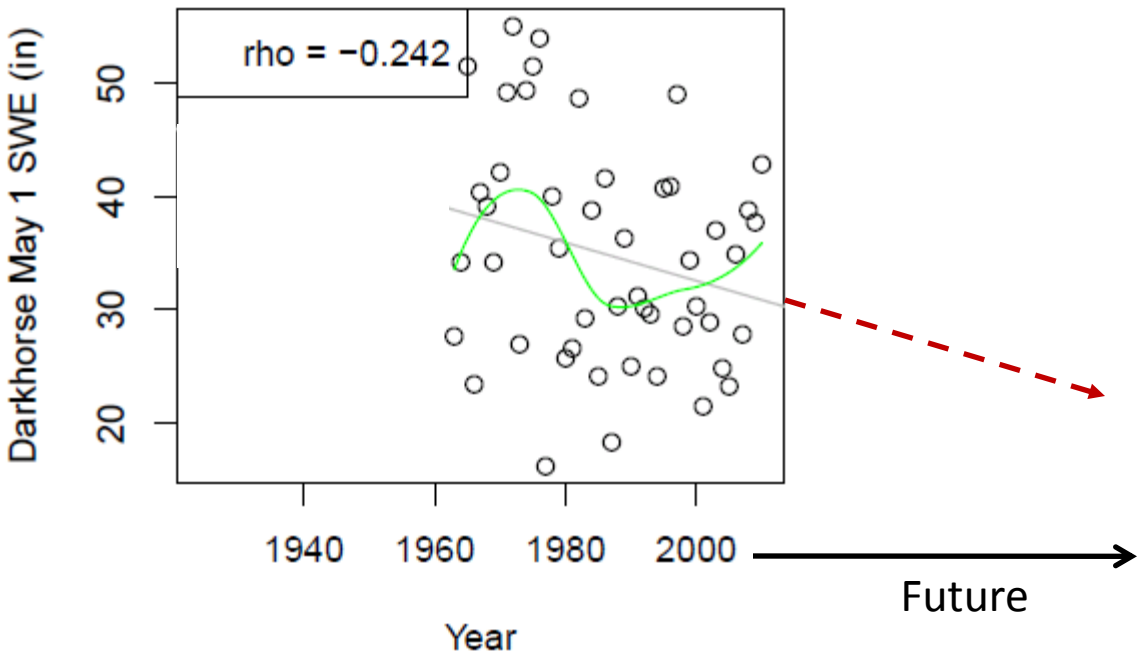
(2) Changes in land use (vegetative index?)

(3) Beaver reintroduction?

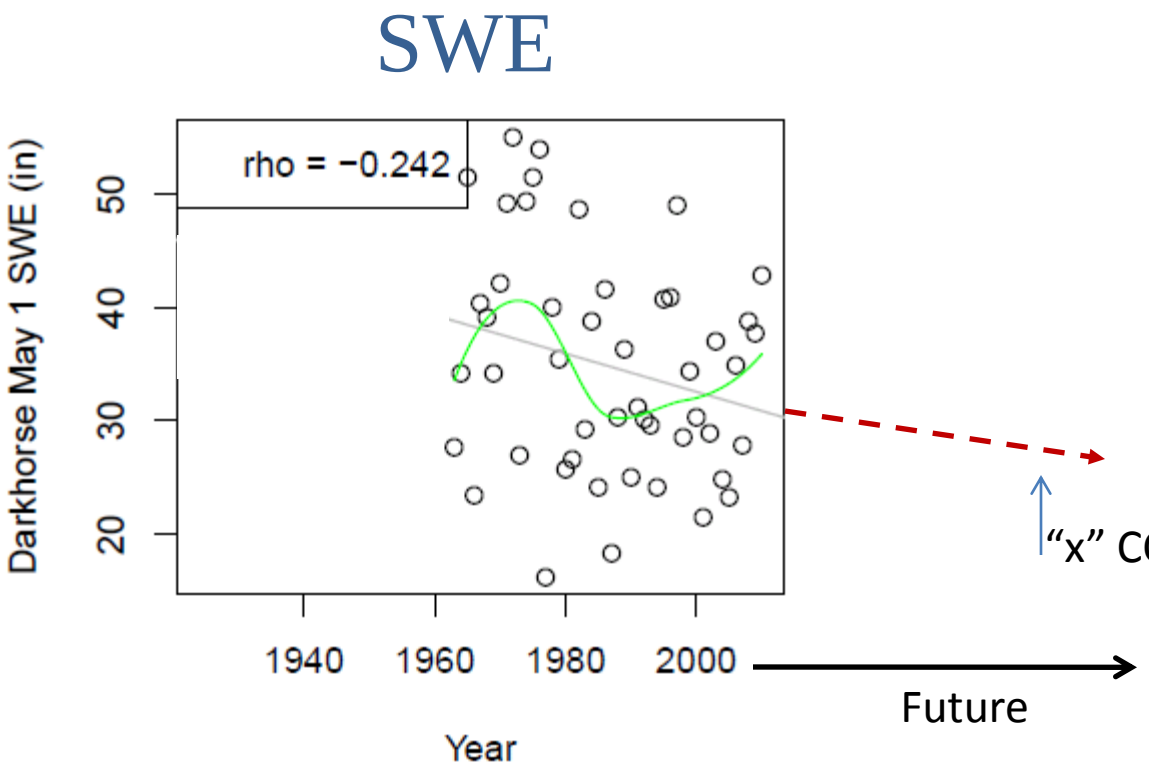
(4) Water leasing?

Adaptation requires identifying level of management needed to offset likely SWE decrease

SWE

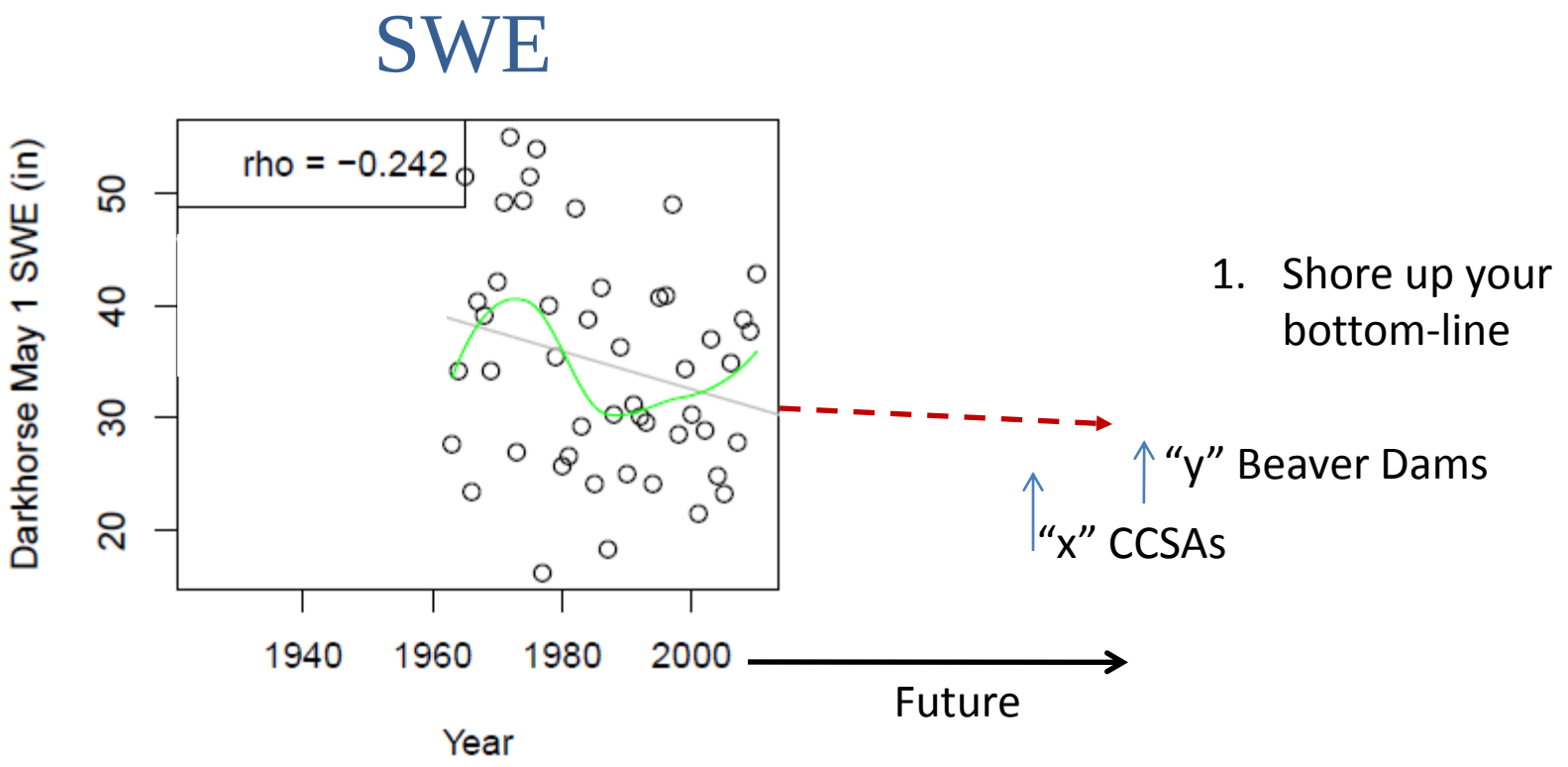


Adaptation requires identifying level of management needed to offset likely SWE decrease

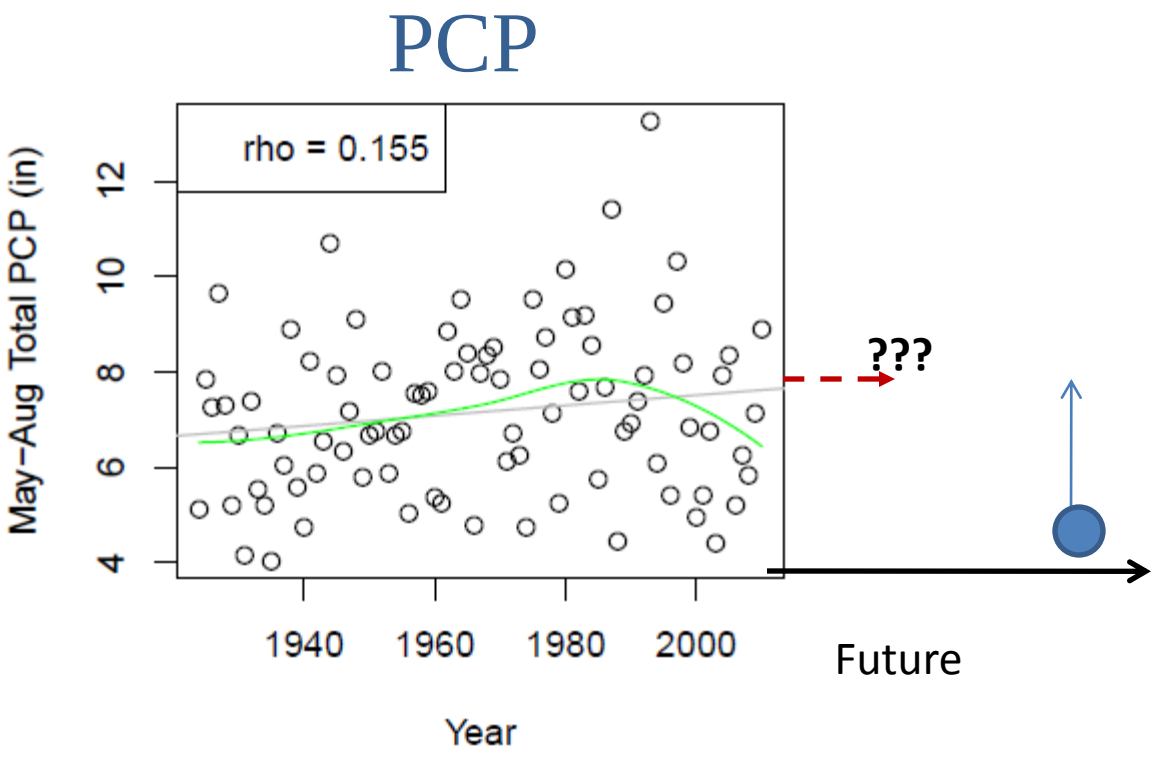


1. Shore up your bottom-line

Adaptation requires identifying level of management needed to offset likely SWE decrease

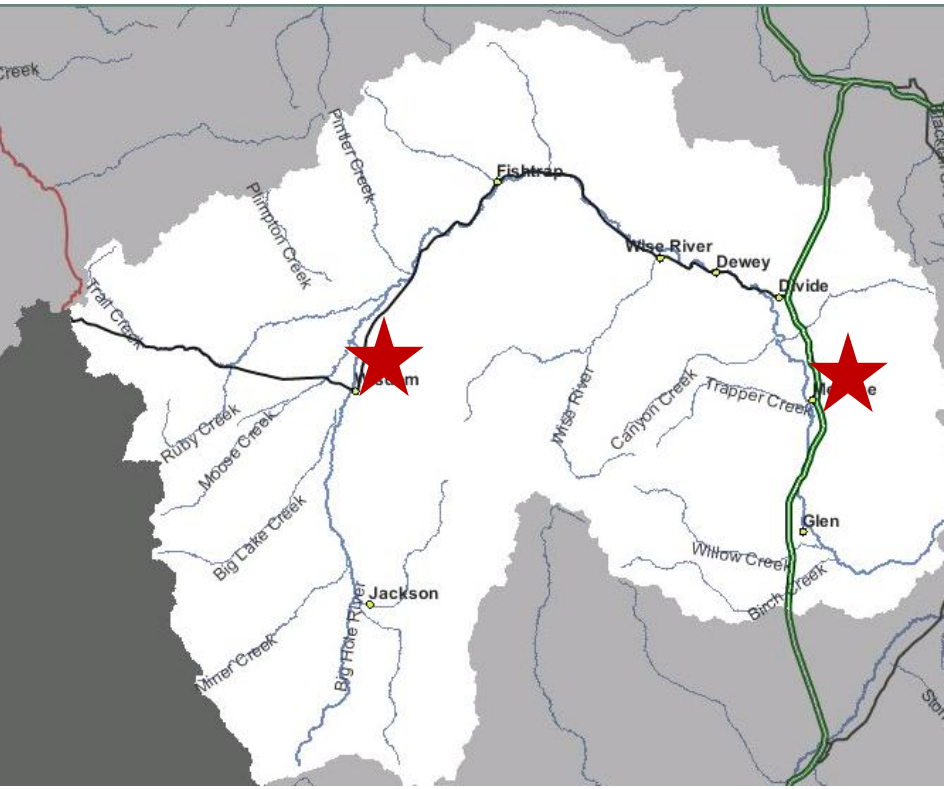


Flexibility will increase resilience to PCP uncertainty



Use May 1st forecast to trigger anticipatory actions (water lease?)

One challenge is the limited record at Wisdom gage

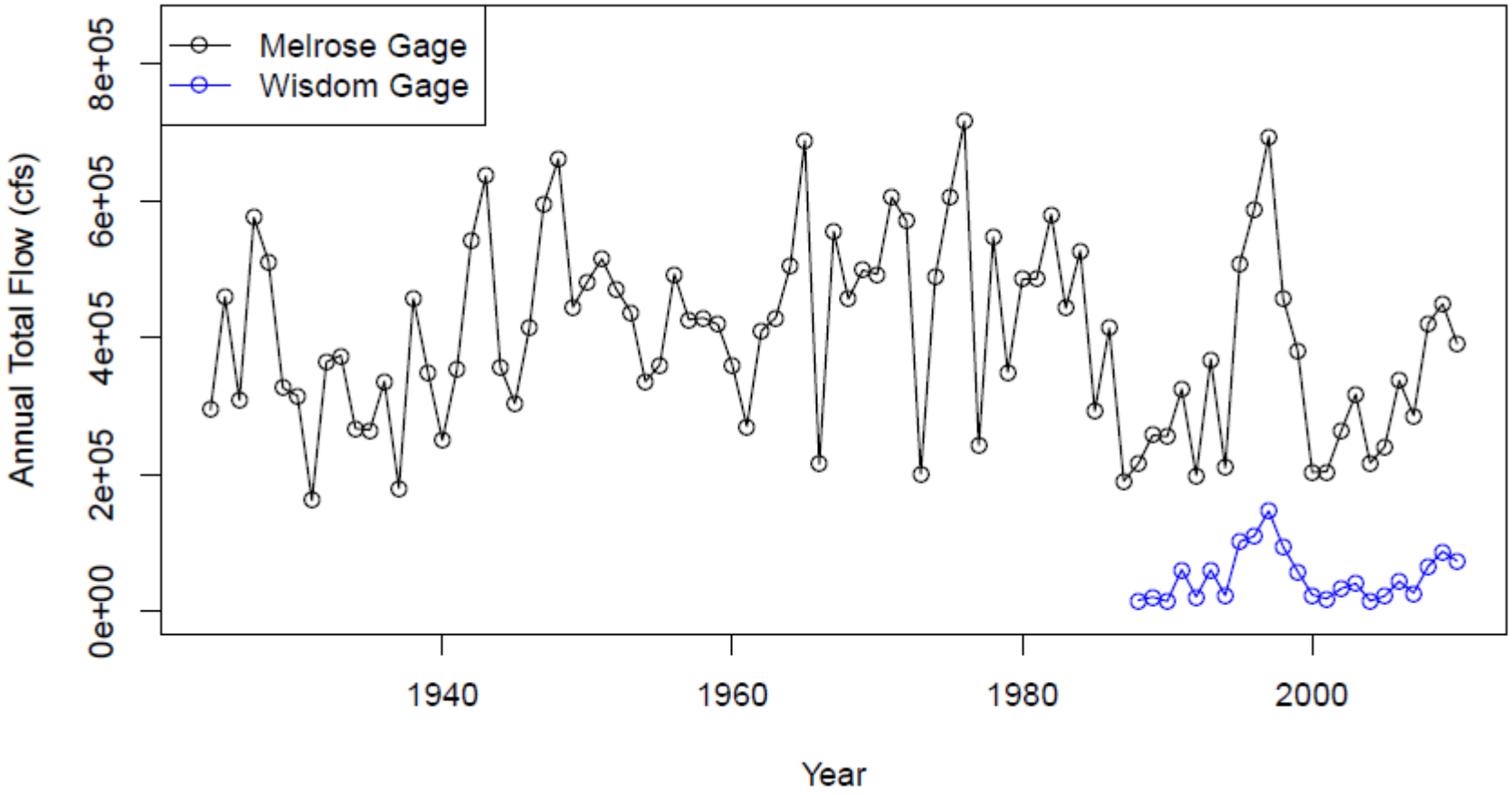


USGS Flow Gage

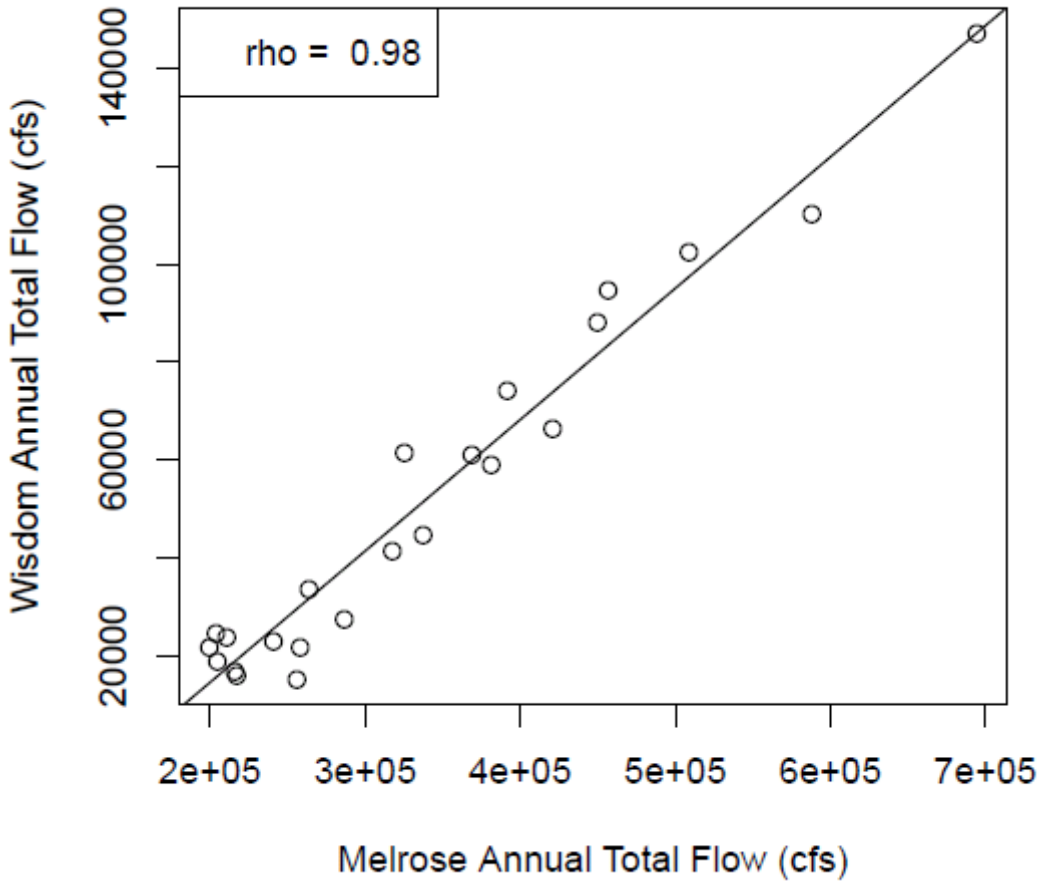
Name	**Wisdom**
Gage	06024450
	Big Hole River bl Big
Location	Lake Cr at Wisdom MT
Dates	1988-present

…but nearby gages have longer records

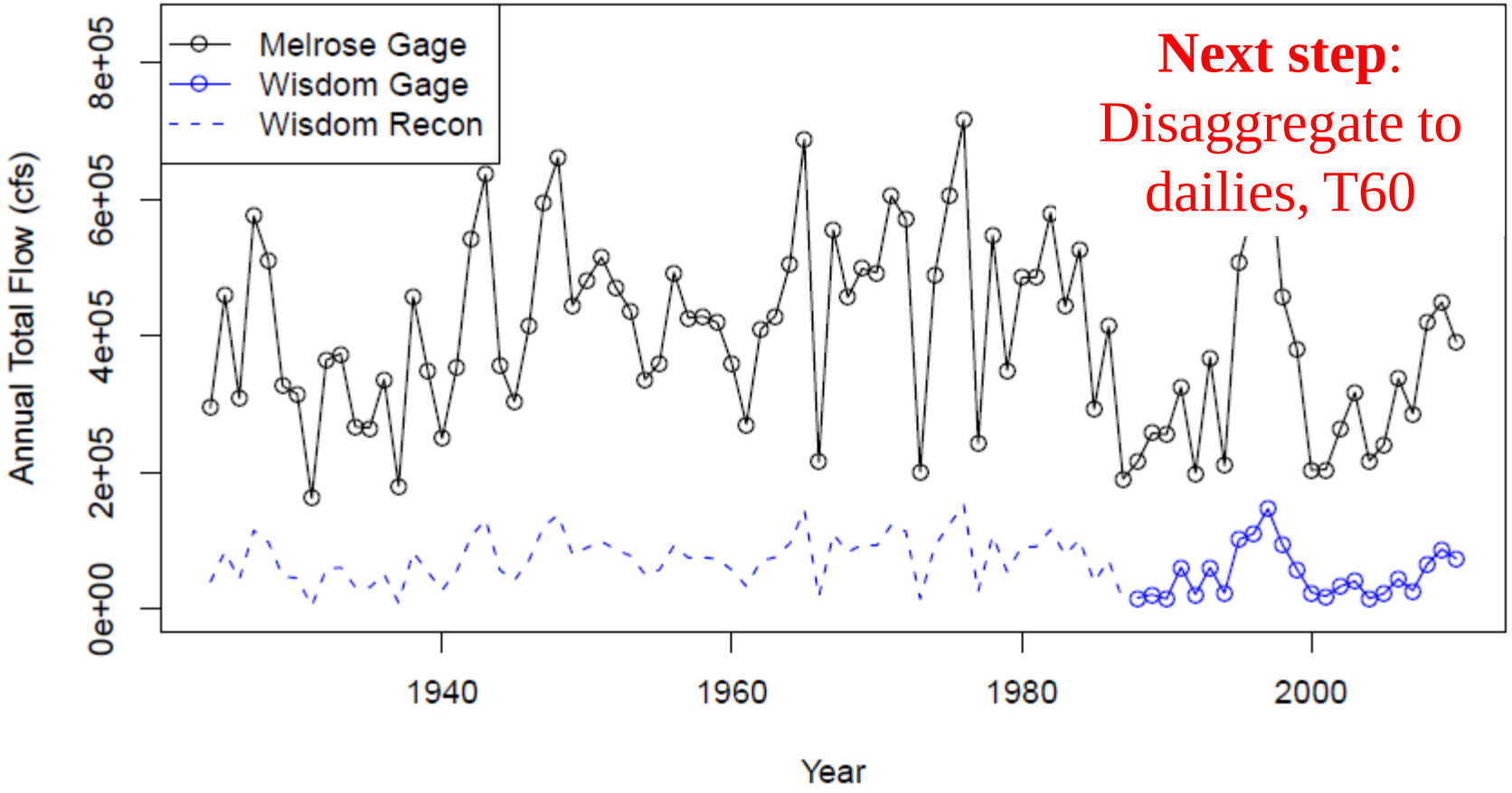
Flow records show annual variability



Annual flows show strong correlation

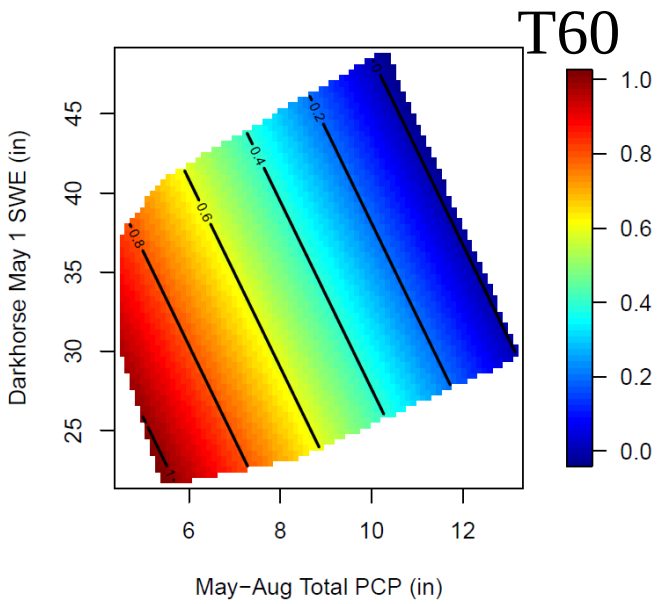


Reconstruction of annual Wisdom flows provides additional context for analysis



Summary and Conclusions,
aka True or False?

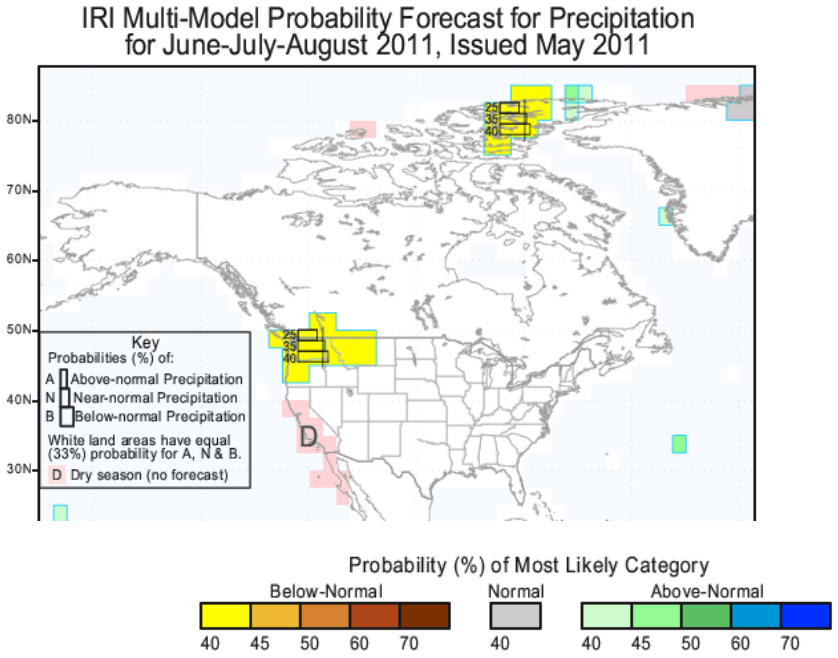
- For decision-making, relating climate directly to a probabilistic threshold (e.g., T60) is more useful than relating it to flow values



True or False?

Summary and Conclusions,
aka True or False?

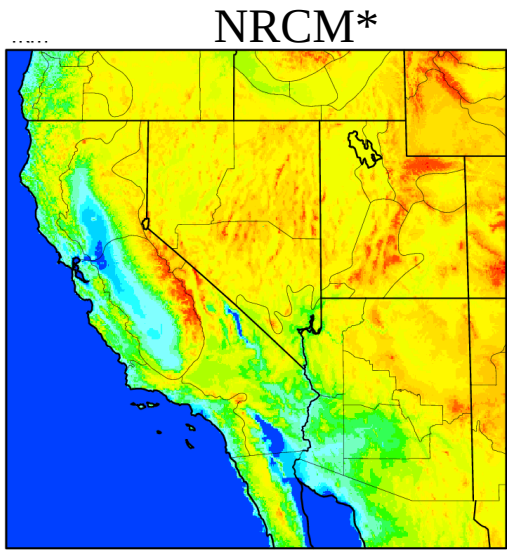
- Having a T60 “forecast” issued May 1st would be useful for decision-making.



True or False?

Summary and Conclusions,
aka True or False?

- Projecting T60 in the future AND quantifying management "offsets" would be useful for adaptation.



True or False?

Thanks!

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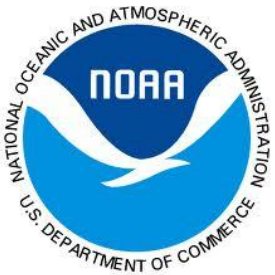
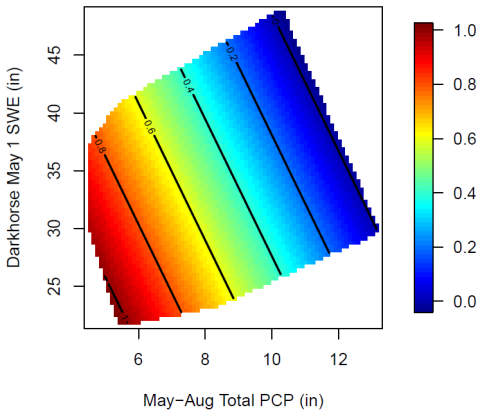
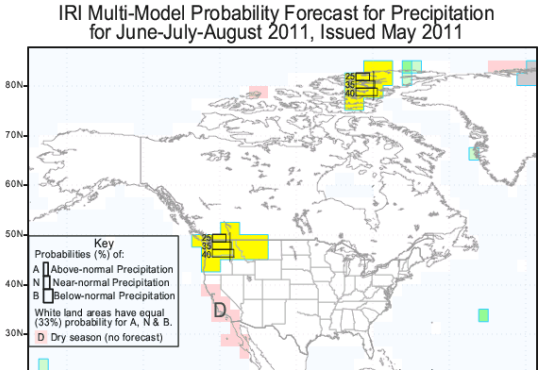


Discussion

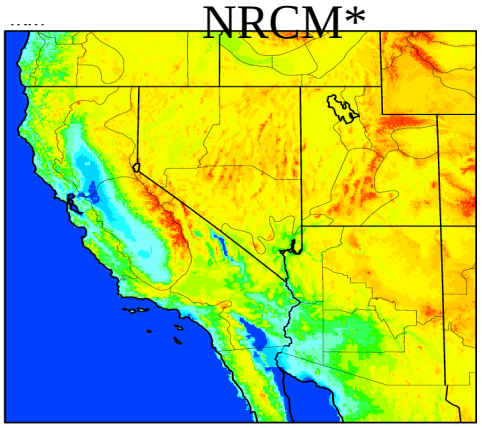
(i) T60 more useful than flows?



(ii) May 1st forecast?



(iii) Future adaptation



(iv) Other important predictors?

$$T60 = f(??)$$

(v) Other key considerations or questions for me?